Comparison of Copper Oxide Needles with Traditional Anthelmintics for the Control of Gastrointestinal Parasites in Growing Meat Goats

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Introduction

The meat goat industry is the fastest growing animal industry in the USA. The number of goats that have been slaughtered in the United States has risen from approximately 50,000 head in 1977 to over 400,000 head in 1998. Recent surveys have shown that approximately 53 million people were identified as potential goat meat consumers. If the annual per capita goat meat consumption were 1 kg, there would potentially be a $450 million industry (Sahlu, 2000).

Gastrointestinal parasites are a major source of economic loss in small ruminant production systems throughout the world. Meat goats in the United States are not an exception. Due to reduced growth rate, weight loss, illness, and death, gastrointestinal parasites cause great economic losses each year for producers. Anthelmintics are the traditional method of treatment against gastrointestinal parasites.

The three main groups of anthelmintics to treat goats against gastrointestinal nematodes are the benzimidazoles, the imidazothiazoles, and the macrolides. The problem of resistance of *Haemonchus contortus* and other gastrointestinal parasites to anthelmintics is a great concern for producers. Resistance to the benzimidazoles and the imidazothiazoles has been reported for several years worldwide, including the United States (Kochapakdee et al., 1995; Hong et al., 1996; Chartier et al., 1998; Barton et al., 1985; Miller and Craig, 1988). Programs designed to reduce the occurrence of parasite resistance to anthelmintics and to help with parasite control are being tested and implemented on many farms. Minimal use of effective drenches, avoidance of under dosing, annual rotation of anthelmintics groups, better pasture management, monitoring the animals for efficacy of anthelmintics, and the importance of nutrition are being emphasized in these programs (Barger, 1993). Integrated control programs would allow producers to rely less

on anthelmintics and help to preserve the anthelmintics that have not yet presented a problem with parasite resistance.

Other problems associated with traditional anthelmintics include withdrawal times and safety in pregnant or lactating animals. These circumstances together with the persistent demands of the public for organically raised, chemical-free animal products, are forcing producers and researchers to devise new, effective, and economical methods of parasite control. Copper oxide needles could be a possible alternative to anthelmintics and part of an integrated parasite control program. This study was trying to determine the efficacy of copper oxide wire needle boluses against naturally acquired strongyle infections and to compare those results to the traditional anthelmintics, Levasol *(levamisole)* and Panacur *(fenbendazole)*.

Literature Review

Trichostrongyloid nematodes are especially common and pathogenic in grazing ruminants. These are usually located in the abomasum and small intestines of ruminant animals (Bowman, 1999). *Ostertagia circumcincta, Trichostrongylus axei,* and *Haemonchus contortus* are a few of the most common trichostrongyles found in goats. These species are found in the abomasum and are regularly associated with morbidity, mortality, and production losses worldwide (Smith and Sherman, 1994). *Haemonchus contortus* is the species of trichostrongyle commonly found around the United States and the world, and especially so in subtropical and tropical regions, where *H. contortus* is the dominant species infesting ruminants (Anderson, 1992). In addition, *H. contortus* is regarded as one of the most pathogenic helminths in domesticated ruminant animals (Anderson, 1992).

Haemonchus contortus is the most important and most common blood-sucking trichostrongyle of goats (Sood and Kaur, 1975). Naturally acquired populations of *H. contortus* may remove one fifth of the circulating erythrocyte volume per day from lambs at peak infection (Bowman, 1999), resulting in anemia. As plasma protein is lost, edema occurs in the subcutaneous tissue. This frequently occurs as submaxillary edema, given the name "bottlejaw."

In order to know how and when to use parasite control measures, one must first understand the life cycle of *H. contortus*. During the females' life span of a few months, they can produce as many as 10,000 eggs per day (Zajac and Moore, 1993). The sexually mature female lays a large number of eggs in the abomasum of the host, which are passed out of the body in the feces. The larvae develop inside of the eggs. If the eggs of *H. contortus* receive sufficient warmth and moisture, the larvae will hatch within 24 hours and molt to the second larvae stage. For nourishment, they continue to stay in the feces and feed on microorganisms. A subsequent molt is started but not completed for the larvae to develop to the third stage (L3). At this point in their development, they are infective for the goats. Under favorable conditions, the whole process from egg hatching to the infective stage can occur within three to four days. Ingestion of the L3's by feed or water is followed by penetration of the lining of the gastrointestinal tract. At this point, the larvae can remain dormant in the host if adverse environmental conditions are not suitable for the larvae outside of the host. When pasture conditions become more favorable for the larvae, they reach sexual maturity and mate to produce fertile eggs. The period from the time of ingestion of the larvae until the eggs are passed in the feces is a minimum of fifteen days in nonimmune animals (Zajac and Moore, 1993).

Temperature and moisture play an important role in the survival of the infective larvae. Migration to the top of the leaf blades in the morning and evening enhances ingestion of the

infective larvae (Smith and Sherman, 1994). Moisture was found to favor larval migration (Roger, 1939). A study conducted by Sood and Kaur (1975) showed that the infective *H. contortus* larvae could survive for 140, 110, 77, 40, 33, and 3 days at 25, 30, 34, 37, 40, and 45°C, respectively. In a temperature range of 14°C to 32°C, *H. contortus* developed more rapidly at the higher temperatures. Below this range, development ceased.

Anthelmintics are the traditional method of treatment of gastrointestinal parasites. As stated earlier, the three main groups of anthelmintics to treat goats against gastrointestinal nematodes are the benzimidazoles, the imidazothiazoles, and the macrolides. These groups contain several anthelmintics, but only phenothiazine and thiabendazole have been approved for goats (Conder and Campbell, 1995). Unlike sheep, goats have a relatively poor ability to increase an effective immune response against gastrointestinal nematodes (Jackson, 2000). The most effective method of determining resistance is to examine post-mortem animals that have been treated versus untreated animals. Because this is impractical in most situations, taking fecal egg counts is another approach. Resistance is assumed if there is less than a 95% reduction in fecal egg counts when compared to a susceptible population (Craig, 1993).

The resistance of gastrointestinal parasites to traditional anthelmintics is one of the primary concerns facing meat goat producers. Factors such as under dosing, dosing too often, and not rotating anthelmintics have contributed to the resistance of many gastrointestinal parasites to certain anthelmintics. In fact, resistance to all classes of anthelmintics has been extensively documented in sheep and goats (Conder and Campbell, 1995; Miller and Craig, 1988; Gill et al., 1995). It is important to determine the background of the farm management practices and the history and origin of the goats to understand how resistance might have occurred in each individual case. The doses used in some cases are the doses recommended for

sheep. As goats metabolize anthelmintics faster than sheep, resistance may have been dose-related.

Programs designed to reduce the occurrence of parasite resistance to anthelmintics and to help with parasite control are being tested and implemented on many farms. According to a study (Cabaret, 2000), insufficient dosages is one of the main reasons for the escalating problems of anthelmintic resistance. For many years, goats have been given the same dosage of anthelmintics as sheep. The dosage of most anthelmintics for goats may need to be doubled from the recommended dosage for sheep and cattle (Varady et al., 1993). Goats have a more rapid clearance of the drugs than sheep. The frequent use of anthelmintics also allows for greater opportunities for selection of resistant parasites (Waller, 1993). An effective program that would slow the occurrence of resistance of nematodes to anthelmintics involves grazing management, use of anthelmintics, and the dependence on acquirement of immunity in the animal against parasites (Brunsdon, 1980).

Integrated control programs would allow for producers to rely less on anthelmintics and help to preserve the anthelmintics that have not yet presented a problem with parasite resistance. Pasture management can be a very beneficial practice to aid in the decreased usage of anthelmintics. It must be understood that the amount of time infective larvae are able to survive on the pasture depends on the geographic location of the pasture due to the environmental conditions, such as temperature and precipitation. One strategy is to alternate grazing a pasture with harvesting it for hay or silage or with cropping it. The numbers of infective larvae are reduced by the harvesting process and by the passage of time (Anderson et al., 1987).

Rotational grazing can be used to inhibit the increase of larvae. Animals must be moved frequently enough to prevent reinfection and not allowed to regraze an infected pasture until environmental conditions or other factors have killed the existing larvae.

Grazing goats with cattle could be part of an integrated parasite control program. Parasites are usually host specific. They infect only a certain species or are less pathogenic in a different species (Waller, 1999). Goats and sheep, however, can become infected with the same species of parasites. Therefore, they cannot be considered alternate species (Zajac and Moore, 1993). A study grazing lambs with sheep only or with cattle and sheep demonstrated that multi-species grazing can help suppress the rate of infection of larvae in lambs (Jordan et al., 1988).

Another alternative that could be incorporated into an integrated control program would be to orally administer copper oxide wire needles (boluses). The question of a possible interaction between blood serum copper concentrations and worm burdens in sheep was raised as early as 1906 (Louw, 1995). Recent studies in New Zealand and Australia have established that use of copper oxide wire needles can reduce *H. contortus* and *Ostertagia* numbers in infected sheep. Bang et al. (1990a&b) reported an interaction between copper metabolism and gastrointestinal nematodes, and have demonstrated anthelmintic activity by copper oxide wire particles against nematodes in experimentally infected sheep. More recently, Chartier et al. (2000) indicated that copper oxide needles had a significant anthelmintic effect on pre-existing *H. contortus* burdens in experimentally infected goats, whereas no effect was recorded against other gastrointestinal nematodes. The same authors concluded that by lowering the number of *H. contortus* worms and the related egg output, copper oxide needles might help to reduce reliance on conventional anthelmintics in goats.

Copper nutritional requirements for goats are not well defined and trace mineral mixes manufactured specifically for meat goats are presently not available commercially. The copper oxide needles, or boluses of wire particles, administered orally to sheep and goats in previous studies contained 4 g copper oxide, equivalent to 3.4 g of metallic copper (Chartier et al. 2000; León et al., 2000). However, a recent study (Luginbuhl et al., 2000) demonstrated that goats are not as susceptible to increased copper levels as sheep. If copper oxide needles, given orally in bolus form, prove to be successful in reducing *H. contortus* in goats, the lower susceptibility of goats to copper may lead to the development of copper oxide boluses targeted specifically to that ruminant species.

Materials and Methods

A field study was conducted at the North Carolina State University's Meat Goat and Forage Lab located in Raleigh, North Carolina at approximately 35°49' N latitude and 78°45' W longitude. The field site, which predominately consists of bermudagrass, has never been grazed by animals before and was mowed for hay in previous years. The field was divided into five sections of equal length and width, along with a sixth section of equal area. Each of the six sections had an area of three-tenths of an acre. Each section, or plot, was separated by portable fence consisting of electro-netting. The fencing was charged with a solar charger.

The field was pre-contaminated with sixty-three yearling meat goats. Random fecal samples were taken from the yearlings to ensure that the field would be contaminated, and the does averaged 475 eggs per gram of feces, while the wethers averaged 658 eggs per gram of feces. The yearlings were rotated every twenty-four hours, for twelve days, at the rate of fifteen-

hundredths of an acre per day. The pasture was then left rest until the bermudagrass had grown back enough to start grazing.

Eighteen yearling wethers and eighteen yearling does, all consisting of percentage Boer and of an average weight of 87.9 kg, were used in a two- to three-month study. Prior to the initiation of the study, fecal samples were taken from the rectum of each goat, and fecal egg counts (FEC) determined (Paracount-EPG™, 1984) to assess the degree of worm infestation. The animals were then weighed, stratified by FEC and body weight, and sorted in groups according to FEC and body weight. Each group consisted of six goats total, which included three wethers and three does, and was randomly assigned to one of two treatments, with three replications in a randomized complete block design. The treatments were: (T1) Deworming with Levasol *(levamisole)* (11mg/kg body weight) and Panacur *(fenbendazole)* (10 mg/kg body weight); and (T2) Administration of copper oxide needle bolus (5g/goat) (Copasur®). All animals had free access to water and a mineral mix (Southern States Sheep Mineral).

Once every two weeks animals were brought to the handling facility and fecal samples were taken directly from the rectum of each animal. Samples were stored in plastic cups with a removable top, transported on ice to the laboratory, and stored in a cooler. Fecal egg counts were determined within five days of sample collection. A fecal floatation solution was made by stirring to dissolve 750 grams of Sodium Nitrate (Champion Bulldog Soda, Nitrate of Soda, 16-0-0, Chilean Nitrate Corporation, Norfolk, VA) in two liters of distilled water. The saturated salt solution was then allowed to stand until the solids settled out and became clear. The clear solution was suctioned off into a glass beaker. A hygrometer was used to check the specific gravity of the clear solution. The specific gravity was adjusted to 1.2 with distilled water or concentrated Sodium Nitrate, depending on whether it was above or below 1.2.

The saturated salt solution was then used to analyze the fecal samples with a modified McMaster technique (Paracount-EPG™, 1984) with a sensitivity of 25 eggs per gram (EPG) or 50 EPG, depending on the concentration of the feces pigmentation. A cylinder, with the height of eighty millimeters and an internal diameter of twenty-five millimeters, was used to measure the correct amounts of salt solution and feces. The cylinder was marked with two lines; one representing the volume needed for twenty-six millimeters of saturated salt solution and the other representing the amount of feces needed on top of the solution to get four grams of feces. After the correct amounts each constituent were placed in the cylinder, they were poured into a cup, crushed with a wooden tongue depressor, and strained through a sieve into a clean cup. A pipette was then used to draw up a sample of the filtrate while mixing. The aspirated filtrate was mixed again while drawing up a second sample with a pipette to fill the second chamber of the McMaster counting chamber. All the equipment used for counting was washed with tap water between samples. For the pipette, the use of tap water was followed by a rinse with the salt solution. The equipment was rinsed daily with deionized water after completing the analyses.

Once the McMaster counting chamber was filled, it was allowed to stand undisturbed for fifteen minutes. This time was found to be the amount of time needed to get the maximum number of eggs to float to the top of the slide against the grids before falling back down into the solution of the chamber. A binocular microscope (Standard 20, Fisher Scientific, Raleigh, NC) was used to count strongly-type eggs inside the grids of the McMaster counting chamber. Each chamber was counted, the numbers of eggs added together, and multiplied by 25 or 50, depending on the amount of fresh feces used.

Blood samples were collected for the determination of packed cell volume (PCV) and plasma protein (PP). Blood was taken by jugular venipuncture using 20-guage, 2.54-centimeter

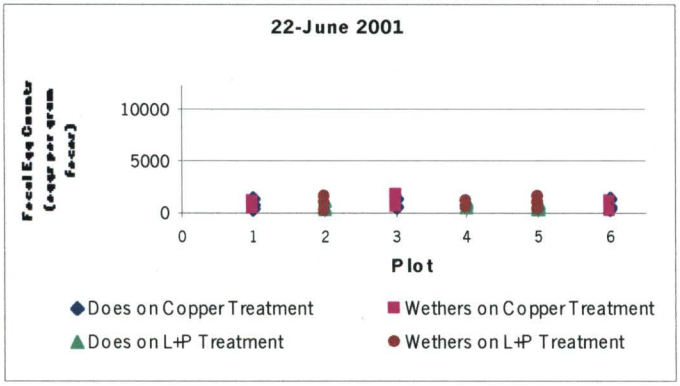
needles and then aspirated into a 10-milliliter glass vacutainer tube containing one-tenth of a milliliter of 15% EDTA solution as an anticoagulant (Becton Dickinson Vacutainer Systems, Franklin Lanes, NJ). The samples were refrigerated until they were analyzed. A Labquake shaker (Barnstead/Thermolyne) was used to keep the samples well mixed prior to filling micro-hematocrit capillary tubes (Fisher Scientific, Raleigh, NC). The capillary tubes were sealed at one end with Seal-ease tube sealer (Clay Adams, Parsippany, NJ) and spun in a microcentrifuge (IEC Micro-HB Centrifuge, Fisher Scientific, Raleigh, NC) at 14,000 rotations per minute for four minutes. After spinning, the packed cell volume (PCV) was read using a micro-capillary reader (Fisher Scientific, Raleigh, NC). The capillary tubes were then broken and one drop of plasma was placed on a refractometer (Fisher Scientific, Raleigh, NC) to determine plasma protein (PP).

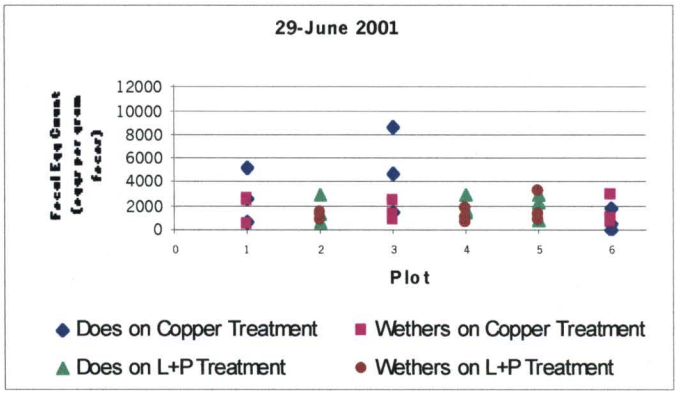
Results

Fecal Egg Count

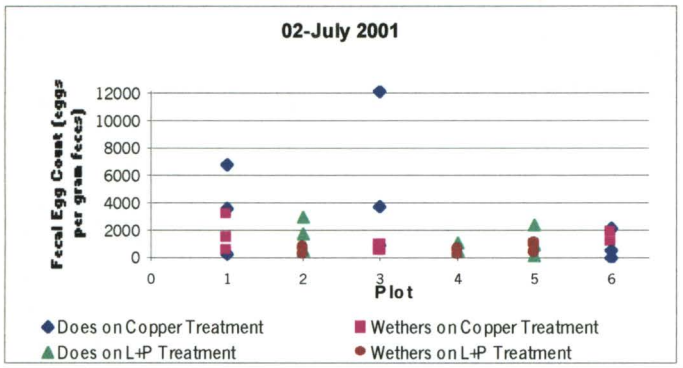
The results for each treatment are given in Tables 1 through 8.

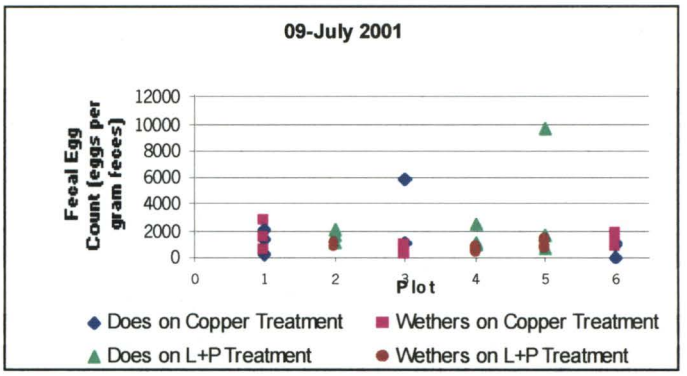
Tables 1-2
Fecal egg counts (eggs per gram feces) vs. Plot

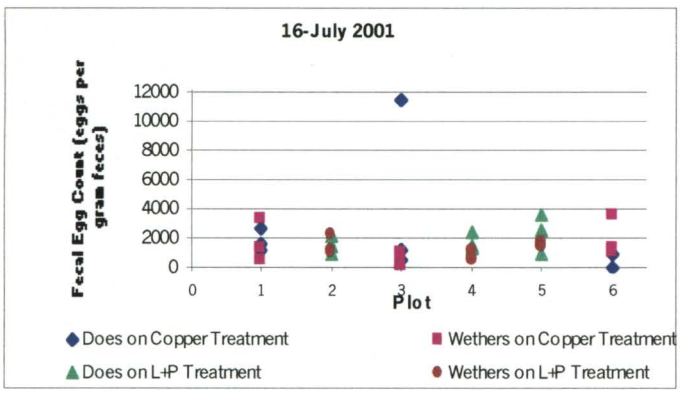


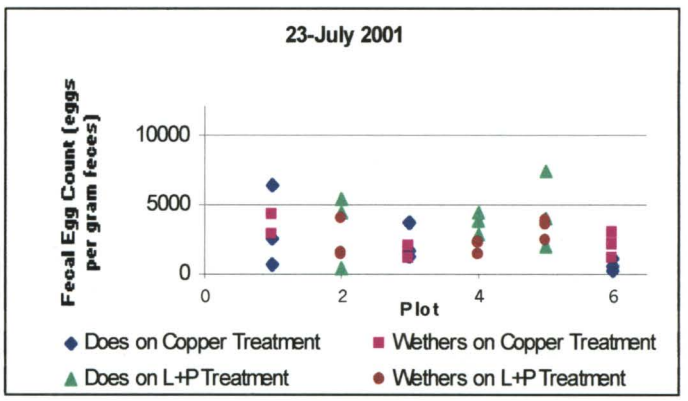


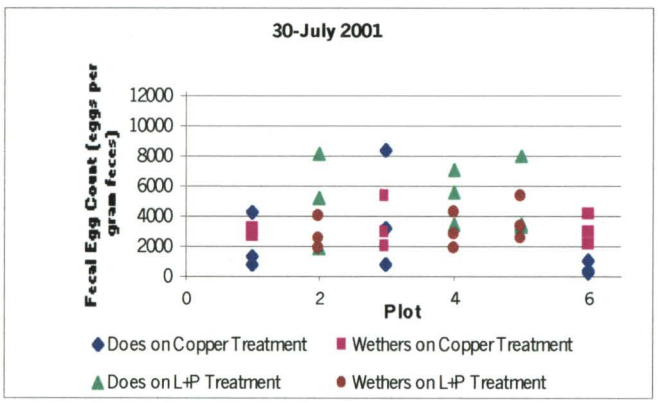
Tables 3-8
Fecal egg counts (eggs per gram feces) vs. Plot

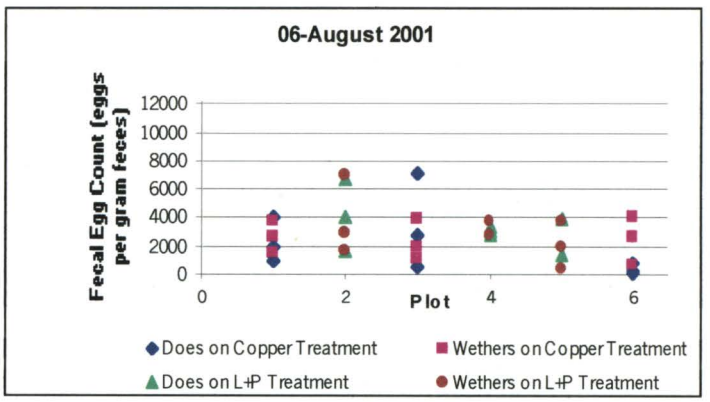






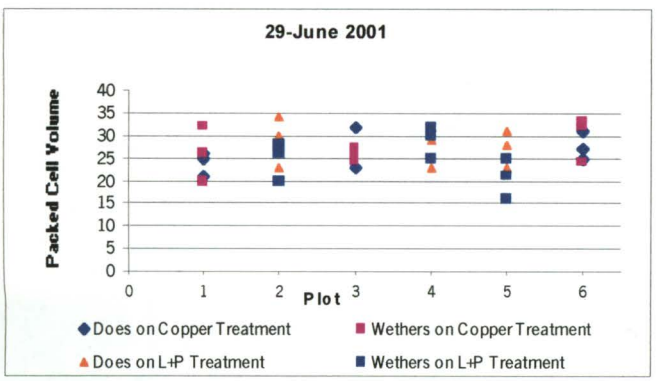


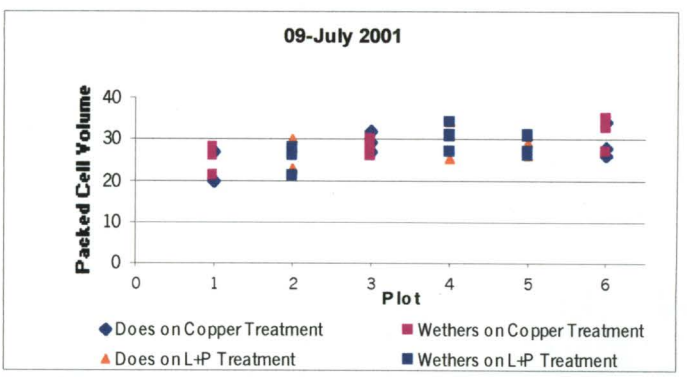




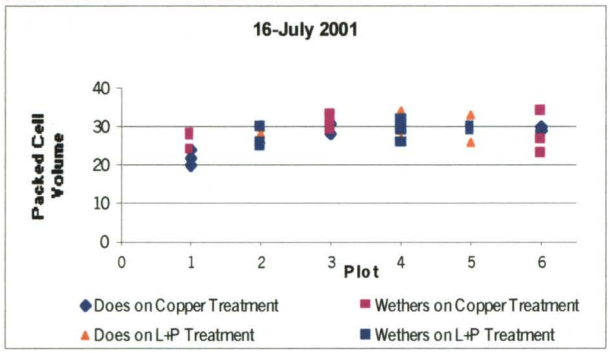
Packed Cell Volume

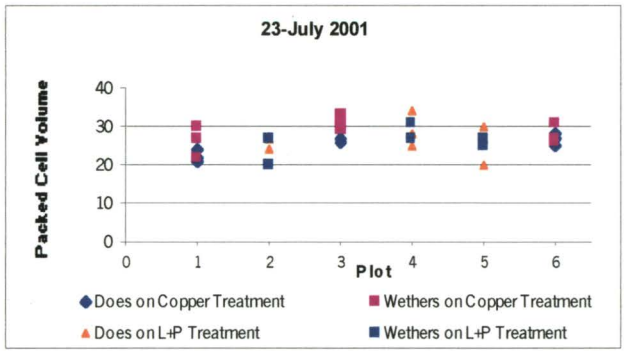
The results for each treatment are given in Tables 9 through 14.

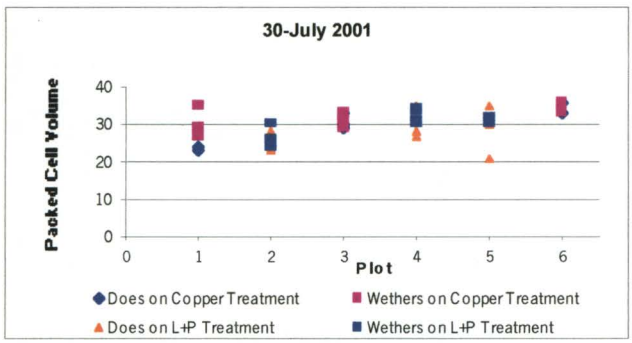


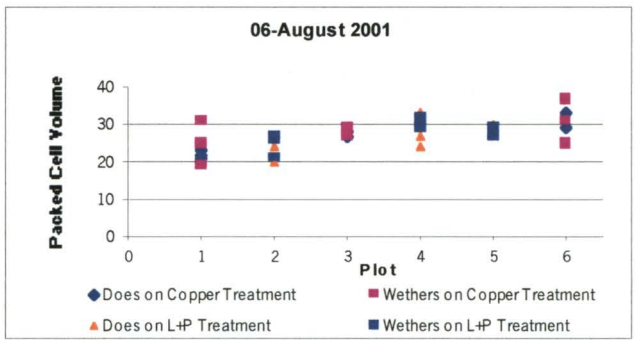


Tables 11-14
Packed Cell Volume vs. Plot





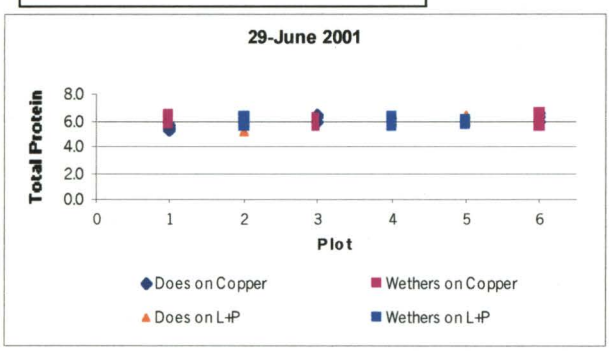


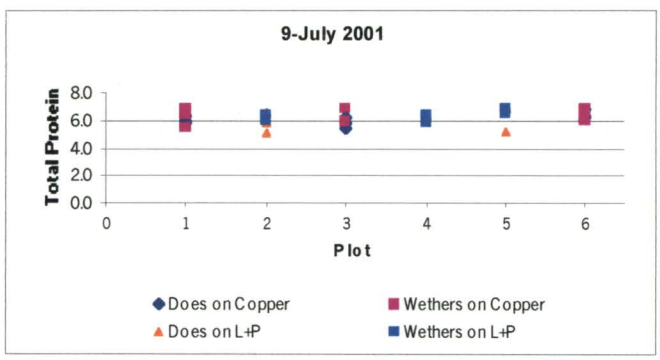


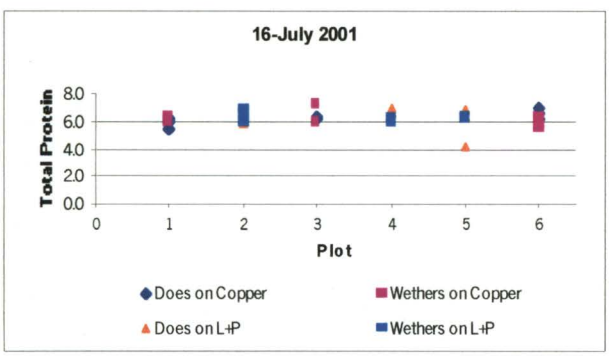
Total Protein

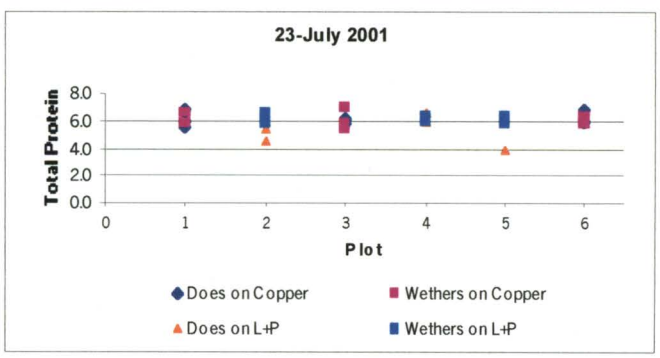
The results for each treatment are given in Tables 15 through 20.

Tables 15-18
Total Protein vs. Plot

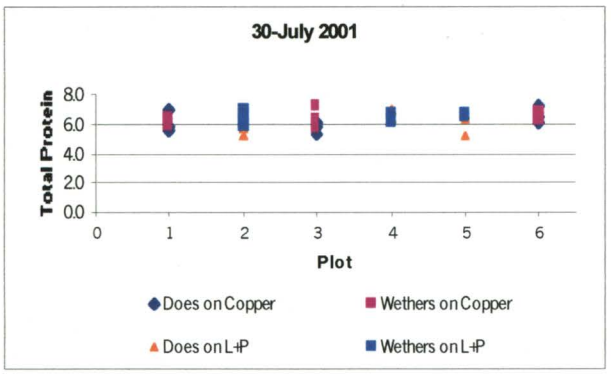


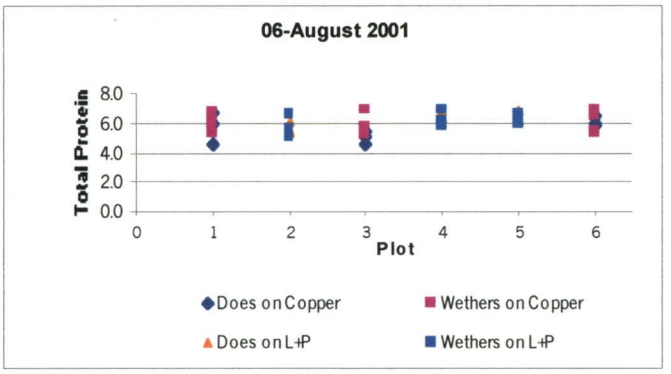






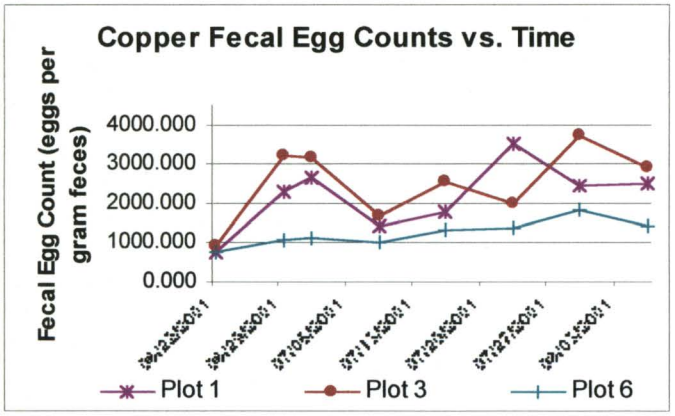
Tables 19-20
Total Protein vs. Plot

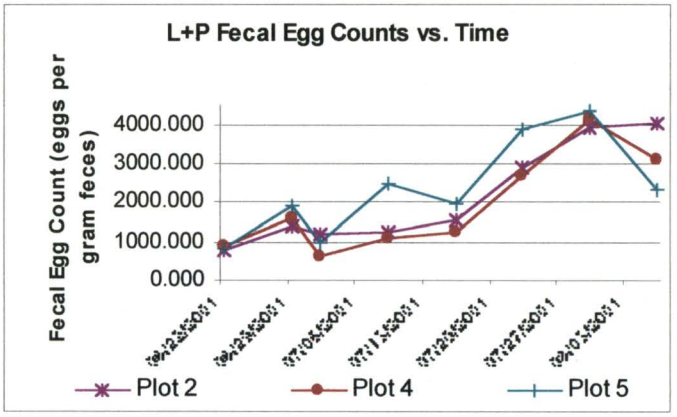




Discussion of Results

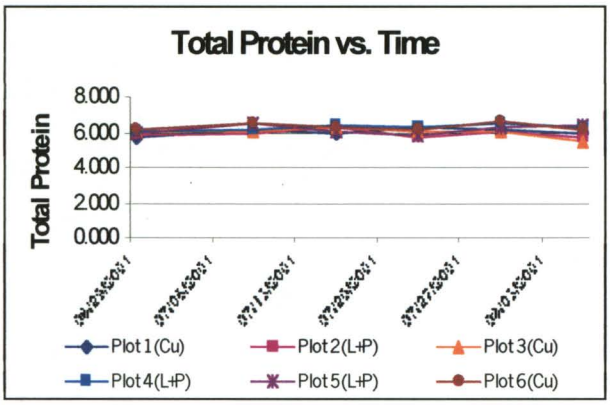
As stated earlier, *Haemonchus contortus* is regarded as one of the most pathogenic helminthes in domesticated ruminant animals. Because of their blood sucking capabilities, their presence leads to lower packed cell volume and blood protein as the number of *H. contortus* increases. Also, when blood plasma protein is lost, edema occurs in the subcutaneous tissue, causing bottle jaw. The measures of blood protein, along with packed cell volume, are indicators of anemia. The results of the study show no relationship between fecal egg counts, packed cell volume and blood protein.

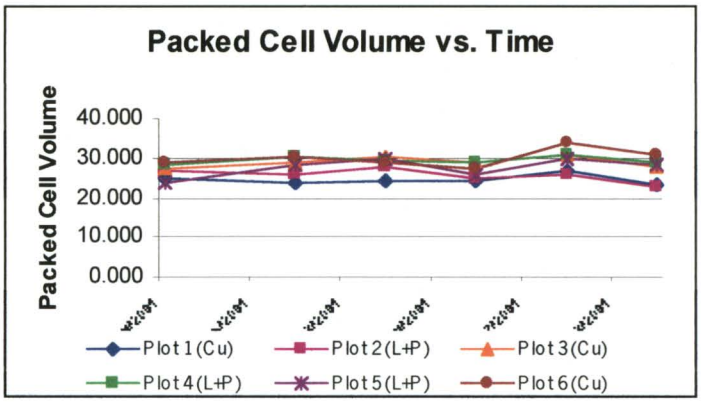




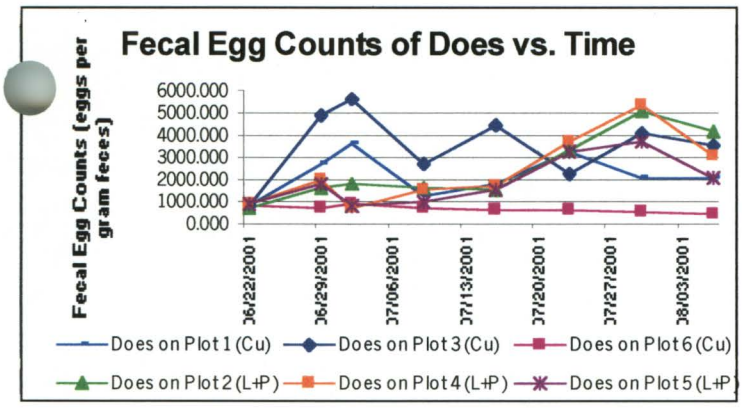
As seen in the graphs above, the Levasol and Panacur (L+P) treatment is, in general, able to keep the FEC lower throughout much of the time period. Traditional anthelmintics have a

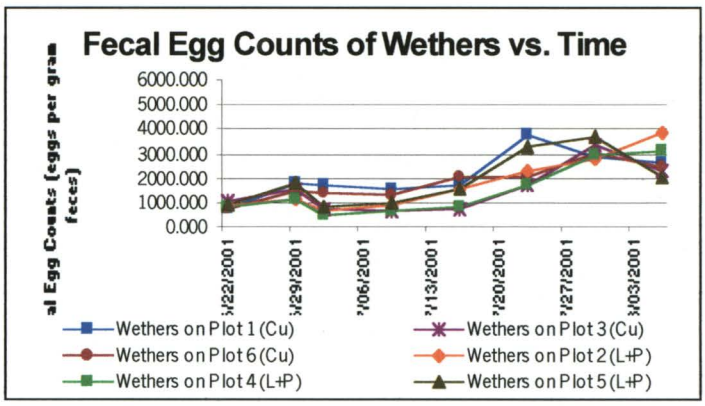
short life of about one week, so the increase is expected throughout time. Also, the copper oxide needles were able to keep the FEC from a sharp increase, and in general, worked on keeping the FEC fairly steady throughout, as compared to the traditional anthelmintics. Because of these increases in FEC, we would expect the packed cell volume and blood protein to decrease in response to the *H. contortus*.



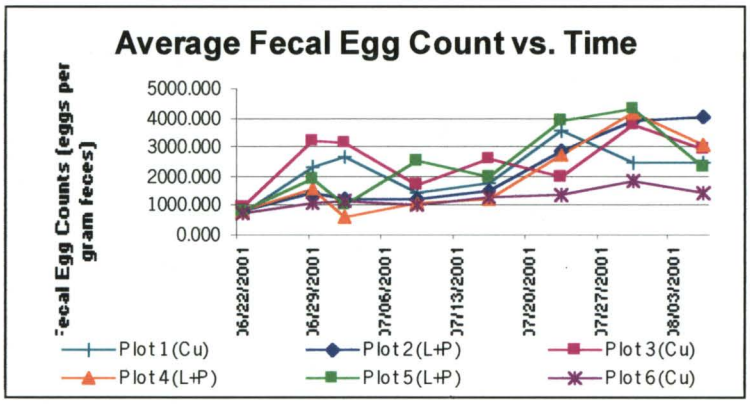


Blood protein and packed cell volume remained constant throughout, as seen in the graphs above, even with the elevated fecal egg counts in the study. This proves that there was no relationship between fecal egg counts, packed cell volume and blood protein. Because the burmudagrass that the goats grazed was of excellent quality (16% protein), this shows that with good nutrition some animals are able to withstand higher fecal egg counts. Animals that would be able to withstand these higher fecal egg counts do not include lactating animals and animals of high maintenance requirements.





The graphs above show the differences between the two sexes of animals: does (female) and wethers (castrated males). With the exception of three of the plots of does, the general trend for all animals of both sexes seems to be fairly consistent.



The graph of average fecal egg counts vs. time for individual plots shows that the only definite trend in the relationship between FEC and plots is that there is an increase in FEC. This shows that plot has no effect on the FEC.

All of these graphs show that there are trends within each, fecal egg count (FEC), packed cell volume (PCV), and total protein. Because the PCV and total protein remain fairly constant throughout with all animals, there is no interaction in this study between FEC and PCV and total protein. Evaluating the differences in sex and plot also show that neither have an effect on FEC. One possible avenue to further explore the topic of using copper oxide wire needles is to clean

up the parasite load from the animals and then give the copper oxide wire boluses in order to help keep a more stable FEC, without having to dose as often, in turn preventing resistance.

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